SNO: Low Energy Calibration using a Neutron-Activated NaI Detector

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The Sudbury Neutrino Observatory (SNO) seeks to measure the shape of the neutrino energy spectrum emitted by the decay of ^{8}B in the Sun. Calibration of the detector throughout the energy range of solar neutrinos is critical for the accurate measurement of the charged current spectral shape. We will use a neutron-activated NaI detector to measure the low energy response of SNO and here report on our preparatory experiments and Monte-Carlo simulations.

Neutron capture by ^{23}Na in the NaI detector produces ^{24}Na ($t_{1/2}$= 15 hrs). The ^{24}Na decays by the emission of a β^- followed promptly by two γ-rays with energies of 2.754 and 1.368 MeV. ^{127}I in NaI also undergoes thermal neutron capture, but results in the short-lived isotope ^{128}I ($t_{1/2}$=25.5 min). The activated NaI may be used as a triggered calibration source because the β^- will always deposit energy in the NaI detector, while the γ-rays will often exit the detector (for the small crystals we are considering) to create Čerenkov light in the D_2O. Thus a signal from the detector may be used to trigger SNO to look for the Čerenkov light from the γ-rays.

We conducted an experiment in which a 3"×3" NaI detector was activated for 24 hours by thermal neutrons. The activated NaI detector was placed within a second, large bore annular NaI detector, which was used to determine the spectra of emitted γ-rays. The activated NaI energy spectrum shows four β-like features due to the summing of the β and the two γ-rays in four posible combinations: β only, β + 1.368, β + 2.754 and β + 1.368 + 2.754. The individual γ-ray peaks are emphasized in the annular NaI spectrum by placing gates in the appropriate region of the activated NaI energy spectrum. These peaks are displayed in Figure 1.

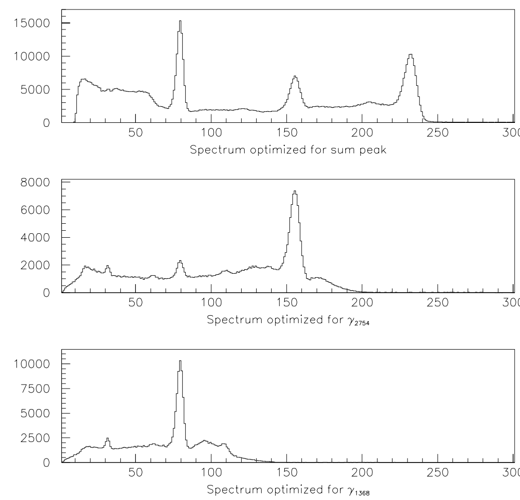

Figure 1: The energy of the γ-rays which escape the activated detector when gates are set on the activated NaI energy spectrum.

We assessed the ability of the γ-ray peaks to generate signals observable in SNO through use of the Monte Carlo code SNOMAN. Activated NaI detectors of various sizes were simulated. Two results were apparent: 1) The energy of the β is sufficiently low so as to be contained within the detector, and 2) detectors smaller than 2"×2"enhance the escape of both γ-rays, while those larger allow a higher probability of the absorption of one of the γ-rays within the activated NaI, resulting in a chance to obtain up to three calibration points for SNO at low energies.

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‡Die Arbiet wurde mit Unterstützung eines Stipendiums im Rahmen des Gemeinsamen Hochschulsonderprogramms III von Bund and Ländern über den DAAD ermöglicht.